

"Made available under NASA sponsorship  
in the interest of early and wide dis-  
semination of Earth Resources Survey  
Program information and without liability  
for any use made thereof."

TYPE II (JULY 1, 1973)

Title: Structural and Lithologic Study of Northern Coast Ranges and  
Sacramento Valley, California

Principal Investigator: Ernest I. Rich  
School of Earth Sciences  
Stanford University  
Stanford, California 94305

Proposal No: SR 042

GSFC Identification No: UN 217

(E73-10698) STRUCTURAL AND LITHOGRAPHIC  
STUDY OF NORTHERN COAST RANGES AND  
SACRAMENTO VALLEY, CALIFORNIA Progress  
Report (Stanford Univ.) 8 p HC

N73-25390

Unclas  
00698  
CSCL 09F G3/13

REPRODUCED BY  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
U.S. DEPARTMENT OF COMMERCE  
SPRINGFIELD, VA. 22161

PROBLEMS:

Long delay in receiving color composites requested.

ACCOMPLISHMENTS:

During the reporting period (January 1 to June 30, 1973), the following progress toward the objectives of the project can be reported:

1. A preliminary map of the various linear features in the Northern California Coast Ranges and Sacramento Valley was completed using ERTS-1 imagery available during the reporting period. This includes imagery obtained by ERTS from August through October, 1973. Most of the work was concentrated in the Klamath Mt. and Modoc Plateau region of northern California. The map is in the process of revision, based on more recent imagery received at the end of the reporting period.

2. Photogeologic evaluation of the various lithologic types within the project area was begun using ERTS imagery available at the beginning of the reporting period. Preliminary "test-plots" were selected for monitoring. These "test-plots" are small areas known by the Principal Investigator to be underlain by one or more of the lithologic types. Seasonal changes in photogeologic characteristics will be monitored as subsequent imagery is received and studied.

3. Work has begun on an analysis of geomorphic regions within the project area. Geomorphic regions, or regimes, have been defined, for purposes of this evaluation, as those areas having similar drainage density and texture, similar topographic "grain" or texture, and, in some instances, similar relations to adjacent regimes (i.e., alluvial fans adjacent to the Coast Range and Sierra Nevada foothill belts). Preliminary review suggest that some of the geomorphic regimes clearly reflect the underlying geology and if these relations are detectable on subsequent imagery, the procedure may prove useful in deciphering the geology of other regions. Refinement of this phase of the work will continue.

## SIGNIFICANT RESULTS

As described in an earlier report, the analysis of the ERTS data has disclosed three potentially important linear systems within the Northern Coast Ranges and Sacramento Valley, California. The Coastal and Central systems are chiefly confined to the Coast Ranges and the Valley system was detected in the Sierra and Coast Range foothill belts and in the alluviated part of the Sacramento Valley.

A preliminary geomorphic analysis of the Northern Coast Ranges discloses that the geomorphic characteristics of the area underlain by the Coastal system are much different from those associated with the Central system in the core of the Coast Ranges. Within the Coastal system, or Coastal belt, the drainage networks are moderately fine-textured and have moderately high-density (in a qualitative sense). Although many of the master drainages are parallel with the Coastal linear system, the headward tributaries form a modified directional trellis pattern. The topographic "grain" of the Coastal belt is in part controlled by the San Andreas fault and its associated subsidiary fault zone; however, east of the San Andreas Fault zone the topographic "grain" or texture is slightly oblique to the fault, appears to be made up of a crudely aligned ridge and valley topography, and the effective relief is moderate. On the other hand the drainage networks within the Central system are coarse-textured and of relatively low-density. The drainage has developed no definite pattern (classified here as deranged) although in parts of the area (i.e. San Francisco Bay region and near the southern boundary of the Klamath Mts: Frame 1094-18231 and 1095-18283) a subparallel or colinear drainage pattern can be detected. The topographic "grain" of the area is poorly defined, but locally is controlled by the northwest-trending Central system of linears. The topographic relief in the area ranges from about 500 to 7000 feet above sea level.

From these data and from direct photogeologic interpretation of the imagery, the region associated with the Coastal system appears to be underlain by rocks which are similarly resistant to erosion and were structurally deformed in a uniform manner, compared to the Central system. The area associated with the Central system seems to be underlain by an heterogeneous assemblage of rock types which vary in their resistance to erosion and the structural deformation appears much less uniform and more disordered although locally it is subparallel to the linears.

The geomorphic character of the region just east of the Central system of lineations is one of fine-textured, high-density drainage with a well developed trellis drainage pattern. The topography of the region is characterized for the most part by north-trending valleys and ridges associated with the sedimentary rocks of the Late Mesozoic Great Valley sequence. The topographic "grain" of the area trends northward, about normal to the Valley system of linear elements, and the geomorphic character of the area is unrelated to the Valley system.

The boundary between the Coastal and central geomorphic regions is poorly defined and, in a few places, the two regions can be separated only approximately. In general, however, the boundary follows the courses of some of the master drainages of the Northern California Coast Range, namely the estuarian system of Tallma Creek near San Francisco, the headwaters of the Russian River from Healdsburg northward, and main stem of the Eel River in its headwaters to the Pacific Coast near Cape Mendocino, northern California. North of Cape Mendocino the Central system borders the coastline. The eastern boundary of the Central geomorphic regions is sharp and clearly defined. It forms a sinuous belt of contrasting topography along the western edge of the Sacramento Valley.

The northeast-trending Valley system of linear elements is very pronounced in the northern part of the Sacramento Valley. Just south of the Klamath Mts., some of the Valley system lineations seem to extend across the Coast Ranges and at the coastline they are coincident with the on-shore extension of the Mendocino Escarpment. Southward from the southern margin of the Klamath Mts., the Valley system crosscuts the Central system of linears and associated geomorphology, but cannot be detected within the Coastal system.

On the basis of very preliminary data from ERTS and a review of existing geologic maps and reports, the following working hypothesis has been formulated:

1. In the northern part of the project area the Valley system of linear elements crosscuts both the Central and Coastal systems and thus may be the youngest of the three linear features. From the ERTS imagery, the geomorphic character and the linear features associated with the Central system terminate abruptly at the boundary with the Coastal system. This suggests that the Central system of linears is older than the Coastal system. Hence, the chronologic order of development of the three systems is, from oldest to youngest: Central system, Coastal system, and Valley system.

2. Many areas within the region underlain by the Central system are known to contain thrust klippen of sedimentary rocks of the Late Mesozoic Great Valley sequence (Rich, 1970, 1971; Swe and Dickinson, 1970; Bailey, Blake, and Jones, 1970; Jones and Irwin, 1971), particularly in the vicinity of Lake Berryessa, Clear Lake, Lake Pillsbury, and the southern margins of the Klamath Mts. The combination of the poorly defined topographic "grain", deranged drainage networks, heterogeneity of rock types, and known overthrust klippen suggest an extremely complicated geologic and geomorphic history within the core of the Coast Ranges.

The Central system of linear features and associated geomorphic characteristics thus may represent the mélange of the Late Mesozoic-Early Tertiary subduction zone along the northern coast of the U.S.

3. The Coastal system of linear features and characteristic topographic depression may have developed in association with the movement along the San Andreas Fault, which according to Atwater (1970) dates from Mid-Tertiary (29 M.Y.B.P.).

4. If the relative chronology of the three linear features outlined in (1) above is correct, then the Valley system of lineaments is probably no older than Mid-Tertiary and may be much younger.

In summary, the recognition on the ERTS imagery of the linear systems in the Northern Coast Ranges and Sacramento Valley and the geomorphic characteristics within the regions defined by these systems suggests a reasonable geologic interpretation consistent with the known geology of the region. If this interpretation should prove valid, the location of, and the time of emplacement of, economic deposits within the region may be more clearly defined.

## COST BENEFIT INFORMATION

Because of the nature of the project, it is difficult to quantify the benefits resulting therefrom; hence much of the following is in qualitative terms.

### 1. Identification and description of practical applications:

The identification of the geologic relationships in the California Coast Ranges and Sacramento Valley, California is based on the photogeologic evaluation of ERTS imagery. The types of information extracted include recognition of geologic structural elements, lithologies, and geomorphic characteristics. The ability to evaluate these factors requires, as far as is known at the moment, a monitoring of the vegetational changes that occur during seasonal changes - in California only 2 times a year - at the change from wet to dry season and from the dry to wet season.

### 2. Agencies and individuals who will use the information:

The practical application of this investigation is in the recognition of geologic relationships that might be favorable to the accumulation of economic mineral deposits, and, conversely, to define regions that most likely will be barren of deposits. Although in most instances the accuracy of identification as to geodetic position and actual geologic relations is limited by both the scale of the imagery and the geologic ability of the interpreter, the data should be valuable to oil and mining companies in a "first-look" exploration program.

Specific to this progress report, if the chronology suggested for the formation of the lineaments is correct, it may establish limits on to the time that favorable structural traps might have

formed beneath the Sacramento Valley and hence eliminate or enhance the probability of oil accumulation in rocks older, or younger, than the fracture system. Similarly, the data obtained from ERTS, concerning the limits of the overthrust belt in the core of the Coast Ranges may provide clues to the origin and location of metallic ore deposits, mercury, chrome, manganese, etc.

In addition to commercial companies, the federal and state agencies that might be users of the data include the U.S. Geological Survey, U.S. Bureau of Reclamation, EPA; California Division of Mines and Geology, California, Division of Water Resources; State and City Governmental agencies concerned with land planning.

3. Assessment of costs and benefits associated with ERTS-type information:

The quality of the ERTS imagery as compared to other types of information, at the same scale, is far more comprehensive and to a trained geologist should yield better and more detailed results. The cost in man-hours to collect, and plot on a map the data contained on one 1:1 million ERTS photograph would be minor compared to the production of a map of the same area by low altitude photography or ground methods. Because of the small scale of ERTS images their effectiveness in detailed geologic work is limited, however.

The synoptic and repetitive view of large areas available from ERTS imagery cannot be duplicated by other methods and I believe that their value as a method for "first look" or reconnaissance work will have an enormous impact on the scientific and economic aspects of geologic exploration.

I would have no way of evaluating the cost benefit, but the location of one average sized \$50-100 million oil field by use of satellite imagery methods would certainly have socio-economic benefits. Whether or not this can be done, only time will tell.



U.S. DEPARTMENT OF COMMERCE  
National Technical Information Service

N73-25390

STRUCTURAL AND LITHOLOGIC STUDY OF NORTHERN  
COAST RANGES AND SACRAMENTO VALLEY,  
CALIFORNIA

E. I. Rich

Stanford University  
Stanford, California

July 1973